

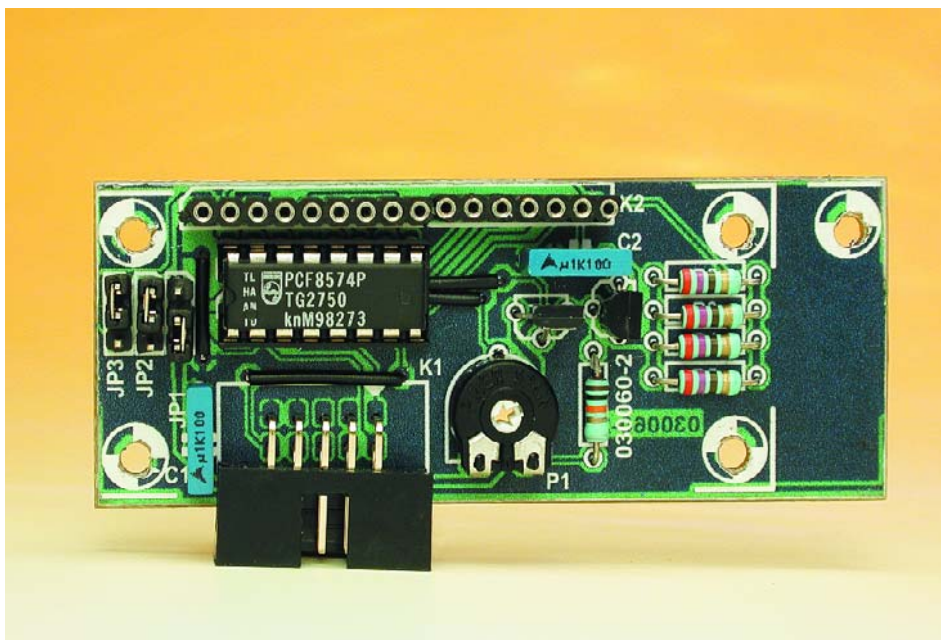
LC Display with I²C Bus

multi-purpose and for the MSC1210 board

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Okay, your microcontroller program is finished and now you want to see some text and other stuff on a display. Unfortunately, the LCD you happen to have available seems to take up rather a lot of precious port pins. Even worse, the driver you've been able to unearth from a software archive seems to rely on other port pins than the ones you had in mind...



Usually, a lot of hard work has been done, including the mental digestion of piles of datasheets, before the first 'Hello World' message appears on your microcontroller system display. We propose an end to this rather wasteful process by describing a universally applicable LC display with a nice set of features, employing the I²C bus which translates

in the use of just 2 (say, two) of the precious port pins on your microcontroller. Admittedly the small printed circuit needed for the universal LCD board represents extra hardware, but you'll soon find that it's well worth the investment.

Clearly this article should discuss

not only hardware, but also software, and that comes in the form of a complete driver (8051 ANSI C source code) which allows you to employ the `lcd_printf()` function without any restrictions. The driver proposed here even allows the outputting of floating point numbers and numbers in larger sizes.

The display solution discussed in this article is especially well suited to battery-operated equipment because the display can be put to sleep by software, reducing its current consumption to just a few micro-amps. Besides, it is possible to set the LCD's I²C address with the aid of a few jumpers (or wire links). Using three jumpers and two available IC variants, up to 16 of these LCD units may be connected to a single I²C bus.

Of course it is possible to omit the LCD and use the board as a simple I²C bus port. That would allow you to connect, for example, a 3 × 4 matrix keypad or a relay driver/interface. However such alternative uses of the board are only discussed in general terms, see the 'PCF8574' inset.

Remote 8-bit I/O expander for the I²C bus

The 10-way boxheader on the board has the same pinning as that on the Precision Measurement Central ('Elektor Meter') board described in the July/August 2003 issue of this magazine. Here, the industry-standard PCF8574 is used as an interface between the LCD and the signals on the I²C bus. The base address of the chip is preset using three jumpers. The default address is # 66 (see 'PCF8574' inset). The display can be just about any alphanumeric type you may have available, as long as it is HD44780 compatible. However, the pins used for the LCD supply and backlighting (if available) should be checked carefully as they may differ between manufacturers.

The board was designed to fit under most commonly found LC display sizes, in particular, those of the 4 × 20 character type. However, smaller types may also be connected without problems. In case of doubt, only the first line of the display may be shown. The display and the board should be secured to one another using PCB spacers. The electrical connection is by short wires.

The display can be switched off by software, which has a nice side-effect in that the display is reset at the same time (which may be necessary every now and then!). The display is operated in 4-bit mode.

The uC/51-ANSI-C Compiler (for all 8051 compatible micros) discussed in parts 1 and 2 of the Precision Measurement Central article may also be used to control the display. All drivers are supplied in the form of source code files, hence need no further discussion here. The compiler and the source code files may be obtained from the Free Downloads section of the *Elektor Electronics* website. The driver itself is pretty compact and requires a minimum amount of memory to work.

On each LC display connected to the bus, up to eight characters can be user-defined, and the driver will initialise them as a substitute for a 7-segment display. The same drivers should also enable you to extend the functionality of the display to your own requirements. A weblink to an

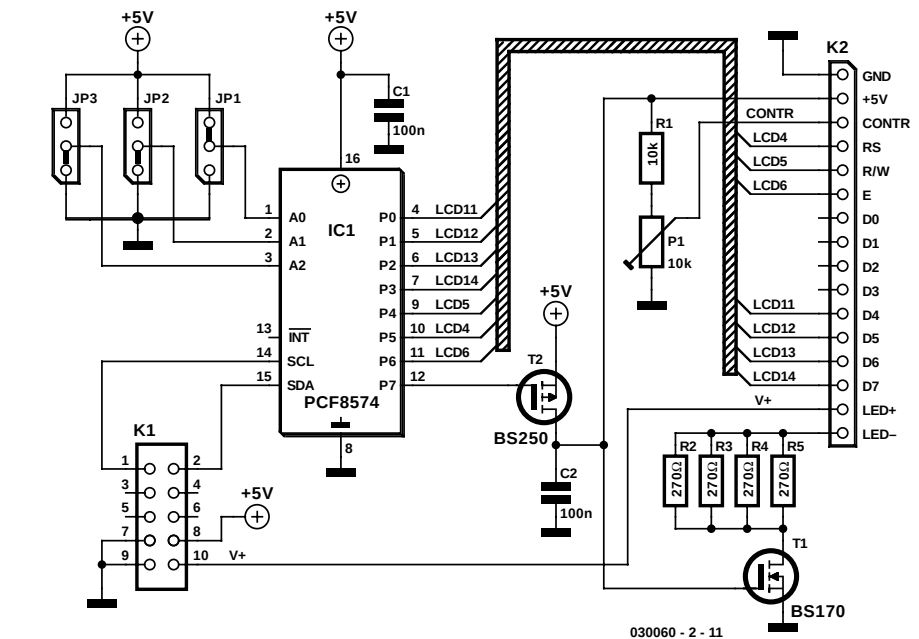


Figure 1. Circuit diagram of the I²C LCD interface.

interesting generator project is included at the end of the article. One rather playful option is to

change the character set during operation — try it for some visually interesting effects like animations.

PCF8574 8-bit I/O Expander for I²C Bus

Elektor Electronics readers know the I²C bus from many projects published in books as well as the magazine, so a discussion of the I²C standard is probably not required here. The PCF8574 offers eight bi-directional, digital, I/O pins. The structure of the individual port pins is hardly different from that of the industry-standard 8051 processor. Simplifying things to some extent, both are 'open drain' lines with weak pull-up resistors. Just as with the 8051, an input may only be read if the relevant port pin has been set to '1' before. The PCF8574 has three address inputs, A0, A1 and A2, which allow up to eight PCF8574's to be connected up to a single I²C bus. There is also a PCF8574A variant which has a different base address. This means that the total number of individually addressable I/O expanders is 16.

Naturally the PCF8574(A) is also perfect for other applications like driving relays or scanning (keyboard) switches.

The addressing follows this structure:

0 1 0 0 A2 A1 A0 0

for the PCF8574 (base address = 64), and

0 1 1 1 A2 A1 A0 0

for the PCF8574A (base address = 112)

The bits for A2, A1 and A0 correspond to the logic levels on the IC pins: '0' for GND and '1' for Vcc.

In the Precision Measurement Central, the I²C address '66' (decimal) is used. So, on the LCD board, jumper 1 should be connected to +5 V (logic level '1') and jumpers 2 and 3, to ground (logic level '0'). The address used is found in the program `LCD_I2C.c`. All activity on the SCL and SDA lines is caused by as well as taken care of by a library (complete with source code texts) that comes with the uC/51 Compiler. Other I²C devices are equally simple to talk or listen to. The library was developed with great care and was found worth its salt in many an industrial application.

Three-layer software

The software written for this project operates at three levels (or layers). At the top level we find the user module. The next lower level is an intermediate module that copies characters to a low-level driver. The driver is also suitable for a direct 4-bit or 8-bit connection to the CPU. To stay within the scope envisaged for this article, only those functions are discussed that are visible to the user. The main functions are:

lcd_init()

initialises the display and activates the oversized numbers in the character set. If everything is okay, a '0' is returned.

lcd_printf()

employs the same parameters as the regular **printf()** command. Return value is the number of characters supplied to the LCD.

lcd_putc()

outputs a single character (like **putc()**).

lcd_cgchars()

copies a 64-byte block into the display character memory. This memory may be located in external RAM or in the microcontroller's program memory.

lcd_d2_printf()

As **printf()**, only all numbers are displayed 'oversized'.

All functions are employed in the demo programs for the Elektor Meter documentation

and described there.

Finally, a few words on timing. Obviously, you will want to be able to use the bus at the highest possible speed. Consequently the software has to be informed about the speed of the controller you are using. In the uC/51 Compiler, that is done using the **CPU_NSEC** macro which indicates the effective time (in nanoseconds) spent on a single CPU instruction. In most cases, this will equate to the average instruction time.

If no display is available, all output is into cyberspace, i.e., goes to waste. Whatever happens, the driver will not remain stuck somewhere, but returns to the main software within a certain time.

The printed circuit board

The *Elektor Electronics* laboratory design for a printed circuit board is

Web links

www.wickenhaeuser.com

Author's homepage. Downloads for ANSI Compiler and drivers.

www.erikbuchmann.de

Javascript generator.

www lcd-module.com

Many LCD datasheets.

given in **Figure 2**. The board may be obtained from The PCBShop under number **030060-2**. As opposed to a SMD version designed by the author, the Elektor board is stuffed with leaded components only. Please note that there are four wire links which should not be forgotten

(030060-2)

COMPONENTS LIST

Resistors:

R1 = 10k Ω

R2-R5 = 270 Ω

P1 = 10k Ω preset

Capacitors:

C1, C2 = 100nF

Semiconductors:

T1 = BS170

T2 = BS250

IC1 = PCF8574(A)P

Miscellaneous:

JP1, JP2, JP3 = 3-way pinheader with jumper (or wire links) (JP1 to +; JP2 and JP3 to ground)

K1 = 10-way boxheader, angled solder pins
PCB, order code **030060-2** from The PCBShop

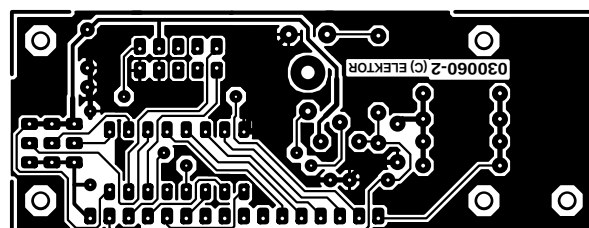
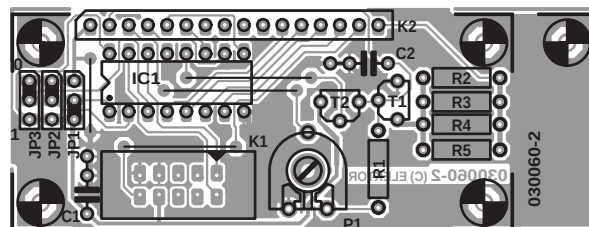


Figure 2. Layout of the single-sided printed circuit board.